

02152042P

证 明

CERTIFICATE

本证明之附件是向中国专利局作为受理局提交的下列国际申请副本
THIS IS TO CERTIFY THAT ANNEXED HERETO IS A TRUE COPY OF THE BELOW
IDENTIFIED INTERNATIONAL APPLICATION THAT WAS FILED WITH THE
CHINESE PATENT OFFICE AS RECEIVING OFFICE

国 际 申 请 号: PCT/CN03/00047

INTERNATIONAL APPLICATION NUMBER

国 际 申 请 日: 20 JAN 2003 (20. 01. 2003)

INTERNATIONAL FILING DATE

发 明 名 称 : System and Method for Calibrating a Hard Disc
TITLE OF INVENTION Drive Magnetic Head Flying Height Tester by
Optical Interference Techniques

申 请 人: SAE MAGNETICS(H.K.)LTD
APPLICANT

中华人民共和国国家知识产权局局长
COMMISSIONER OF THE STATE INTELLECTUAL PROPERTY
OFFICE OF THE PEOPLE'S REPUBLIC OF CHINA

王景川

二零零三年二月二十四日
FEBRUARY. 24. 2003

HOME COPY

PCT

REQUEST

The undersigned requests that the present international application be processed according to the Patent Cooperation Treaty.

For receiving Office use only

International Application No.

PCT/CN 03/0 00 47

International Filing Date

20 JAN 2003 (2 0 0 1 0 3)

RO/CN

中华人民共和国国家知识产权局

PCT International Application

Name of receiving Office and "PCT International Application"

Applicant's or agent's file reference
(if desired) (12 characters maximum)

FPPEL02150042

Box No. I TITLE OF INVENTION

System and Method for Calibrating a Hard Disc Drive Magnetic Head Flying Height Tester by Optical Interference Techniques

Box No. II APPLICANT

☐ This person is also inventor

Name and address: (Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.)

SAE MAGNETICS (H. K.) LTD.
SAE Tower,
38-42 Kwai Fung Crescent
Kwai Chung N. T.
Hong Kong Special Administrative Region,
P. R. of China

Telephone No.

Facsimile No.

Teleprinter No.

Applicant's registration No. with the Office

State (that is, country) of nationality:
CN

State (that is, country) of residence:
CN

This person is applicant
for the purposes of:

all designated
Statesall designated States except
the United States of Americathe United States
of America onlythe States indicated in
the Supplemental Box

Box No. III FURTHER APPLICANT(S) AND/OR (FURTHER) INVENTOR(S)

Name and address: (Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.)

HU, Yanzhan
Winnerway Industrial Area,
Nancheng, Dongguan City
Guangdong Province,
P. R. of China Zip Code: 511700

This person is:

☐ applicant only

☐ applicant and inventor

☒ inventor only (If this check-box
is marked, do not fill in below.)

Applicant's registration No. with the Office

State (that is, country) of nationality:

State (that is, country) of residence:

This person is applicant
for the purposes of:

all designated
Statesall designated States except
the United States of Americathe United States
of America onlythe States indicated in
the Supplemental Box

Further applicants and/or (further) inventors are indicated on a continuation sheet..

Box No. IV AGENT OR COMMON REPRESENTATIVE; OR ADDRESS FOR CORRESPONDENCE

The person identified below is hereby/has been appointed to act on behalf of the applicant(s) before the competent International Authorities as:



agent

common
representative

Name and address: (Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country.)

CHINA PATENT AGENT (H.K.) LTD.
22/F, Great Eagle Centre
23 Harbour Road, Wanchai
Hong Kong Special Administrative Region
The People's Republic of China

Telephone No.

(852)28284688

Facsimile No.

(852)28271018

Teleprinter No.

Agent's registration No. with the Office



Address for correspondence: Mark this check-box where no agent or common representative is/has been appointed and the space above is used instead to indicate a special address to which correspondence should be sent.

Sheet No. ...2...

Continuation of Box No. III FURTHER APPLICANT(S) AND/OR (FURTHER) INVENTOR(S)	
<i>If none of the following sub-boxes is used, this sheet should not be included in the request.</i>	
Name and address: <i>(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.)</i> LI, Yu Winnerway Industrial Area, Nancheng, Dongguan City Guangdong Province, P. R. of China Zip Code: 511700	This person is: <input type="checkbox"/> applicant only <input type="checkbox"/> applicant and inventor <input checked="" type="checkbox"/> inventor only <i>(If this check-box is marked, do not fill in below.)</i> <hr/> Applicant's registration No. with the Office
State <i>(that is, country)</i> of nationality:	State <i>(that is, country)</i> of residence:
This person is applicant for the purposes of: <input type="checkbox"/> all designated States <input type="checkbox"/> all designated States except the United States of America <input type="checkbox"/> the United States of America only <input type="checkbox"/> the States indicated in the Supplemental Box	
Name and address: <i>(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.)</i> TIAN, Hong c/o SAE Magnetics (H.K.) Ltd., SAE Tower, 38-42 Kwai Fung Crescent, Kwai Chung, N.T., Hong Kong Special Administrative Region P. R. of China	This person is: <input type="checkbox"/> applicant only <input type="checkbox"/> applicant and inventor <input checked="" type="checkbox"/> inventor only <i>(If this check-box is marked, do not fill in below.)</i> <hr/> Applicant's registration No. with the Office
State <i>(that is, country)</i> of nationality:	State <i>(that is, country)</i> of residence:
This person is applicant for the purposes of: <input type="checkbox"/> all designated States <input type="checkbox"/> all designated States except the United States of America <input type="checkbox"/> the United States of America only <input type="checkbox"/> the States indicated in the Supplemental Box	
Name and address: <i>(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.)</i> 	This person is: <input type="checkbox"/> applicant only <input type="checkbox"/> applicant and inventor <input type="checkbox"/> inventor only <i>(If this check-box is marked, do not fill in below.)</i> <hr/> Applicant's registration No. with the Office
State <i>(that is, country)</i> of nationality:	State <i>(that is, country)</i> of residence:
This person is applicant for the purposes of: <input type="checkbox"/> all designated States <input type="checkbox"/> all designated States except the United States of America <input type="checkbox"/> the United States of America only <input type="checkbox"/> the States indicated in the Supplemental Box	
Name and address: <i>(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.)</i> 	This person is: <input type="checkbox"/> applicant only <input type="checkbox"/> applicant and inventor <input type="checkbox"/> inventor only <i>(If this check-box is marked, do not fill in below.)</i> <hr/> Applicant's registration No. with the Office
State <i>(that is, country)</i> of nationality:	State <i>(that is, country)</i> of residence:
This person is applicant for the purposes of: <input type="checkbox"/> all designated States <input type="checkbox"/> all designated States except the United States of America <input type="checkbox"/> the United States of America only <input type="checkbox"/> the States indicated in the Supplemental Box	
<input type="checkbox"/> Further applicants and/or (further) inventors are indicated on another continuation sheet.	

Sheet No. ...3...

Box No. V DESIGNATION OF STATES

Mark the applicable check-boxes below; at least one must be marked.

The following designations are hereby made under Rule 4.9(a):

Regional Patent

- ☐ **AP ARIPO Patent:** GH Ghana, GM Gambia, KE Kenya, LS Lesotho, MW Malawi, MZ Mozambique, SD Sudan, SL Sierra Leone, SZ Swaziland, TZ United Republic of Tanzania, UG Uganda, ZM Zambia, ZW Zimbabwe, and any other State which is a Contracting State of the Harare Protocol and of the PCT (if other kind of protection or treatment desired, specify on dotted line)
- ☐ **EA Eurasian Patent:** AM Armenia, AZ Azerbaijan, BY Belarus, KG Kyrgyzstan, KZ Kazakhstan, MD Republic of Moldova, RU Russian Federation, TJ Tajikistan, TM Turkmenistan, and any other State which is a Contracting State of the Eurasian Patent Convention and of the PCT
- ☐ **EP European Patent:** AT Austria, BE Belgium, BG Bulgaria, CH & LI Switzerland and Liechtenstein, CY Cyprus, CZ Czech Republic, DE Germany, DK Denmark, EE Estonia, ES Spain, FI Finland, FR France, GB United Kingdom, GR Greece, IE Ireland, IT Italy, LU Luxembourg, MC Monaco, NL Netherlands, PT Portugal, SE Sweden, SK Slovakia, TR Turkey, and any other State which is a Contracting State of the European Patent Convention and of the PCT
- ☐ **OA OAPI Patent:** BF Burkina Faso, BJ Benin, CF Central African Republic, CG Congo, CI Côte d'Ivoire, CM Cameroon, GA Gabon, GN Guinea, GQ Equatorial Guinea, GW Guinea-Bissau, ML Mali, MR Mauritania, NE Niger, SN Senegal, TD Chad, TG Togo, and any other State which is a member State of OAPI and a Contracting State of the PCT (if other kind of protection or treatment desired, specify on dotted line)

National Patent (if other kind of protection or treatment desired, specify on dotted line):

- | | | |
|--|---|---|
| <input type="checkbox"/> AE United Arab Emirates | <input type="checkbox"/> GM Gambia | <input type="checkbox"/> NZ New Zealand |
| <input type="checkbox"/> AG Antigua and Barbuda | <input type="checkbox"/> HR Croatia | <input type="checkbox"/> OM Oman |
| <input type="checkbox"/> AL Albania | <input type="checkbox"/> HU Hungary | <input type="checkbox"/> PH Philippines |
| <input type="checkbox"/> AM Armenia | <input type="checkbox"/> ID Indonesia | <input type="checkbox"/> PL Poland |
| <input type="checkbox"/> AT Austria | <input type="checkbox"/> IL Israel | <input type="checkbox"/> PT Portugal |
| <input type="checkbox"/> AU Australia | <input type="checkbox"/> IN India | <input type="checkbox"/> RO Romania |
| <input type="checkbox"/> AZ Azerbaijan | <input type="checkbox"/> IS Iceland | <input type="checkbox"/> RU Russian Federation |
| <input type="checkbox"/> BA Bosnia and Herzegovina | <input type="checkbox"/> JP Japan | |
| <input type="checkbox"/> BB Barbados | <input type="checkbox"/> KE Kenya | <input type="checkbox"/> SD Sudan |
| <input type="checkbox"/> BG Bulgaria | <input type="checkbox"/> KG Kyrgyzstan | <input type="checkbox"/> SE Sweden |
| <input type="checkbox"/> BR Brazil | <input type="checkbox"/> KP Democratic People's Republic of Korea | <input type="checkbox"/> SG Singapore |
| <input type="checkbox"/> BY Belarus | <input type="checkbox"/> KR Republic of Korea | <input type="checkbox"/> SI Slovenia |
| <input type="checkbox"/> BZ Belize | <input type="checkbox"/> KZ Kazakhstan | <input type="checkbox"/> SK Slovakia |
| <input type="checkbox"/> CA Canada | <input type="checkbox"/> LC Saint Lucia | <input type="checkbox"/> SL Sierra Leone |
| <input type="checkbox"/> CH & LI Switzerland and Liechtenstein | <input type="checkbox"/> LK Sri Lanka | <input type="checkbox"/> TJ Tajikistan |
| <input checked="" type="checkbox"/> CN China | <input type="checkbox"/> LR Liberia | <input type="checkbox"/> TM Turkmenistan |
| <input type="checkbox"/> CO Colombia | <input type="checkbox"/> LS Lesotho | <input type="checkbox"/> TN Tunisia |
| <input type="checkbox"/> CR Costa Rica | <input type="checkbox"/> LT Lithuania | <input type="checkbox"/> TR Turkey |
| <input type="checkbox"/> CU Cuba | <input type="checkbox"/> LU Luxembourg | <input type="checkbox"/> TT Trinidad and Tobago |
| <input type="checkbox"/> CZ Czech Republic | <input type="checkbox"/> LV Latvia | |
| <input type="checkbox"/> DE Germany | <input type="checkbox"/> MA Morocco | <input type="checkbox"/> TZ United Republic of Tanzania |
| <input type="checkbox"/> DK Denmark | <input type="checkbox"/> MD Republic of Moldova | <input type="checkbox"/> UA Ukraine |
| <input type="checkbox"/> DM Dominica | <input type="checkbox"/> MG Madagascar | <input type="checkbox"/> UG Uganda |
| <input type="checkbox"/> DZ Algeria | <input type="checkbox"/> MK The former Yugoslav Republic of Macedonia | <input type="checkbox"/> US United States of America |
| <input type="checkbox"/> EC Ecuador | <input type="checkbox"/> MN Mongolia | <input type="checkbox"/> UZ Uzbekistan |
| <input type="checkbox"/> EE Estonia | <input type="checkbox"/> MW Malawi | <input type="checkbox"/> VN Viet Nam |
| <input type="checkbox"/> ES Spain | <input type="checkbox"/> MX Mexico | <input type="checkbox"/> YU Yugoslavia |
| <input type="checkbox"/> FI Finland | <input type="checkbox"/> MZ Mozambique | <input type="checkbox"/> ZA South Africa |
| <input type="checkbox"/> GB United Kingdom | <input type="checkbox"/> NO Norway | <input type="checkbox"/> ZM Zambia |
| <input type="checkbox"/> GD Grenada | | <input type="checkbox"/> ZW Zimbabwe |
| <input type="checkbox"/> GE Georgia | | |
| <input type="checkbox"/> GH Ghana | | |

Check-boxes below reserved for designating States which have become party to the PCT after issuance of this sheet:

- | | | |
|--------------------------------|--------------------------------|--------------------------------|
| <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |

Precautionary Designation Statement: In addition to the designations made above, the applicant also makes under Rule 4.9(b) all other designations which would be permitted under the PCT except any designation(s) indicated in the Supplemental Box as being excluded from the scope of this statement. The applicant declares that those additional designations are subject to confirmation and that any designation which is not confirmed before the expiration of 15 months from the priority date is to be regarded as withdrawn by the applicant at the expiration of that time limit. (Confirmation (including fees) must reach the receiving Office within the 15-month time limit.)

Box No. VI PRIORITY CLAIM

The priority of the following earlier application(s) is hereby claimed:

Filing date of earlier application (day/month/year)	Number of earlier application	Where earlier application is:		
		national application: country or Member of WTO	regional application:* regional Office	international application: receiving Office
item (1)				
item (2)				
item (3)				
item (4)				
item (5)				

☐ Further priority claims are indicated in the Supplemental Box.

The receiving Office is requested to prepare and transmit to the International Bureau a certified copy of the earlier application(s) (only if the earlier application was filed with the Office which for the purposes of this international application is the receiving Office) identified above as:

☐ all items ☐ item (1) ☐ item (2) ☐ item (3) ☐ item (4) ☐ item (5) ☐ other, see Supplemental Box

* Where the earlier application is an ARIPO application, indicate at least one country party to the Paris Convention for the Protection of Industrial Property or one Member of the World Trade Organization for which that earlier application was filed (Rule 4.10(b)(ii)):

Box No. VII INTERNATIONAL SEARCHING AUTHORITY

Choice of International Searching Authority (ISA) (if two or more International Searching Authorities are competent to carry out the international search, indicate the Authority chosen; the two-letter code may be used):

ISA /

Request to use results of earlier search; reference to that search (if an earlier search has been carried out by or requested from the International Searching Authority):

Date (day/month/year)

Number

Country (or regional Office)

Box No. VIII DECLARATIONS

The following declarations are contained in Boxes Nos. VIII (i) to (v) (mark the applicable check-boxes below and indicate in the right column the number of each type of declaration):

Number of
declarations

- | | | |
|---|--|---|
| <input type="checkbox"/> Box No. VIII (i) | Declaration as to the identity of the inventor | : |
| <input type="checkbox"/> Box No. VIII (ii) | Declaration as to the applicant's entitlement, as at the international filing date, to apply for and be granted a patent | : |
| <input type="checkbox"/> Box No. VIII (iii) | Declaration as to the applicant's entitlement, as at the international filing date, to claim the priority of the earlier application | : |
| <input type="checkbox"/> Box No. VIII (iv) | Declaration of inventorship (only for the purposes of the designation of the United States of America) | : |
| <input type="checkbox"/> Box No. VIII (v) | Declaration as to non-prejudicial disclosures or exceptions to lack of novelty | : |

Box No. IX CHECK LIST; LANGUAGE OF FILING

This international application contains:

(a) the following number of sheets in paper form:

request (including declaration sheets) : 5
 description (excluding sequence listing part) : 10
 claims : 5
 abstract : 1
 drawings : 7

Sub-total number of sheets : 28

sequence listing part of description (actual number of sheets if filed in paper form, whether or not also filed in computer readable form; see (b) below) :

Total number of sheets : 28

(b) sequence listing part of description filed in computer readable form

(i) ☐ only (under Section 801(a)(i)),(ii) ☐ in addition to being filed in paper form (under Section 801(a)(ii))

Type and number of carriers (diskette, CD-ROM, CD-R or other) on which the sequence listing part is contained (additional copies to be indicated under item 9(ii), in right column):

This international application is accompanied by the following item(s) (mark the applicable check-boxes below and indicate in right column the number of each item):

Number of items

1. ☒ fee calculation sheet : 1
2. ☒ original separate power of attorney : 1
3. ☐ original general power of attorney :
4. ☐ copy of general power of attorney; reference number, if any: :
5. ☐ statement explaining lack of signature :
6. ☐ priority document(s) identified in Box No. VI as item(s): :
7. ☐ translation of international application into (language): :
8. ☐ separate indications concerning deposited microorganism or other biological material :
9. ☐ sequence listing in computer readable form (indicate also type and number of carriers (diskette, CD-ROM, CD-R or other))
 - (i) ☐ copy submitted for the purposes of international search under Rule 13ter only (and not as part of the international application) :
 - (ii) ☐ (only where check-box (b)(i) or (b)(ii) is marked in left column) additional copies including, where applicable, the copy for the purposes of international search under Rule 13ter :
 - (iii) ☐ together with relevant statement as to the identity of the copy or copies with the sequence listing part mentioned in left column :
10. ☐ other (specify): :

Figure of the drawings which should accompany the abstract: Fig 3a

Language of filing of the international application: EN

Box No. X SIGNATURE OF APPLICANT, AGENT OR COMMON REPRESENTATIVE

Next to each signature, indicate the name of the person signing and the capacity in which the person signs (if such capacity is not obvious from reading the request).



For receiving Office use only

1. Date of actual receipt of the purported international application: 20 JAN 2003 (20.01.03)	2. Drawings: <input type="checkbox"/> received: <input type="checkbox"/> not received:
3. Corrected date of actual receipt due to later but timely received papers or drawings completing the purported international application:	
4. Date of timely receipt of the required corrections under PCT Article 11(2):	
5. International Searching Authority (if two or more are competent): ISA /	6. <input type="checkbox"/> Transmittal of search copy delayed until search fee is paid

For International Bureau use only

Date of receipt of the record copy by the International Bureau:

This sheet is not part of and does not count as a sheet of the international application.

PCT

FEE CALCULATION SHEET

Annex to the Request

For receiving Office use only

International Application No.

PCT/CN 03/0 00 47

20 JAN 2003

(2 0.0 1.03)

Date stamp of the receiving Office

Applicant's or agent's
file reference

FPEL02150042

Applicant

SAE MAGNETICS (H.K.) LTD.

CALCULATION OF PRESCRIBED FEES

1. TRANSMITTAL FEE

CNY500

T

2. SEARCH FEE

CNY1500

S

International search to be carried out by CN

(If two or more International Searching Authorities are competent to carry out the international search, indicate the name of the Authority which is chosen to carry out the international search.)

3. INTERNATIONAL FEE

Basic Fee

Where item (b) of Box No. IX applies, enter Sub-total number of sheets } 28

Where item (b) of Box No. IX does not apply, enter Total number of sheets

b1 first 30 sheets CHF650 b1

b2 number of sheets in excess of 30 x fee per sheet = b2

b3 additional component (only if sequence listing part of description is filed in computer readable form under Section 801(a)(i), or both in that form and on paper, under Section 801(a)(ii):

400 x fee per sheet = b3

Add amounts entered at b1, b2 and b3 and enter total at B CHF650 B

Designation Fees

The international application contains 1 designations.

1 x CHF140 = CHF140 D
number of designation fees payable (maximum 5) amount of designation fee

Add amounts entered at B and D and enter total at I CHF790 I

(Applicants from certain States are entitled to a reduction of 75% of the international fee. Where the applicant is (or all applicants are) so entitled, the total to be entered at I is 25% of the sum of the amounts entered at B and D.)

4. FEE FOR PRIORITY DOCUMENT (if applicable)

P

5. TOTAL FEES PAYABLE

CNY2000CHF790

Add amounts entered at T, S, I and P, and enter total in the TOTAL box

TOTAL

☐ The designation fees are not paid at this time.

MODE OF PAYMENT

☒ authorization to charge
deposit account (see below)

☐ postal money order

☐ cash

☐ coupons

☐ cheque

☐ bank draft

☐ revenue stamps

☐ other (specify):

AUTHORIZATION TO CHARGE (OR CREDIT) DEPOSIT ACCOUNT

(This mode of payment may not be available at all receiving Offices)

☒ Authorization to charge the total fees indicated above.

☒ (This check-box may be marked only if the conditions for deposit accounts of the receiving Office so permit) Authorization to charge any deficiency or credit any overpayment in the total fees indicated above.

☒ Authorization to charge the fee for priority document.

Receiving Office: RO

Deposit Account No.

Date: 01/13/2003

Name:

Signature:



**SYSTEM AND METHOD FOR CALIBRATING A HARD DISC DRIVE
MAGNETIC HEAD FLYING HEIGHT TESTER BY OPTICAL
INTERFERENCE TECHNIQUES**

5 Background Information

[0001] The present invention relates to optical gap measuring tool calibration. More specifically, the invention relates to a system and method for calibrating a hard disc drive magnetic head flying height tester by optical interference techniques.

10 [0002] Figure 1 provides an illustration of a typical hard disc drive. In the art of hard disc drives, magnetic read/write heads 102 are commonly integrated in a slider 102 designed to respond to a flow of air moving with the rotating disc 104 over which the slider 102 travels. The head/slider 102 'flies' close to the surface of the disc 104. In manufacturing such heads/sliders 102, it is often necessary to test hydrodynamic characteristics of the heads 102 to verify their performance. It is important that the head
15 102 not travel too far from or close to the disc 104 surface. Further, it is important to prevent the head 102 from traveling at an improper angle with respect to the disc surface 104. A head 102 traveling too high above the disc surface 104 will result in a lower than desired areal density. A head 102 traveling too low can cause an interface failure between the head 102 and disc 104.

20 [0003] In order to test the flying height of the head, a flying height tester is commonly used. Optical interference techniques are often employed to determine the distance between head and disc. A monochromatic light source is directed at a transparent surrogate disc, such as a glass disc, rotating at speeds similar to that of a magnetic disc, and the head assembly being tested is secured in a holder in its normal flying orientation in
25 relation to the disc. The monochromatic light is directed at the disc at a predetermined angle to the surface thereof. The light is reflected from the surface of the disc closest to the head, as well as from the surface of the flying head itself, and impinges onto a light sensitive sensor.

30 [0004] The interference effects created by the combined reflections from the disc and the slider surface provide the flying height information. A computer receives data from the

As flying height tester and calculates the perceived flying height and angle of the head. As hard drives become smaller and increase in data storage capacity, the desired head flying height continually reduces. Therefore, the accuracy of a flying height tester, and thus its calibration, are of critical concern.

5 [0005] Figure 2 illustrates a typical device used to calibrate a flying height tester. A calibration standard, such as is depicted in U.S. Patent Number 5,552,884, is often utilized. As can be seen in figure 2a, the calibration standard includes a mock head 48 in contact with a transparent disc 44 via a load spring 52. The transparent disc 44 has a plurality of grooves 60 formed in a surface facing the mock head 48. A cover case 56 is attached to
10 the glass disc 44 at one end and provides a sealed environment for the interface between the mock head 48 assembly and the transparent disc 44. Several problems exist with the utilization of this device. For example, in establishing H1 204, which is important in evaluating flying height (explained below), the nature of the design causes problems with using optical interference means. Measurement of H1 205 must not be taken too close to
15 a ridge's 64 edge, or else one (or both) of the measurement light beam's return paths 206,208 may travel a portion through air (separated by the walls at 120 and 124). The differences in optical properties between air and the transparent disc (glass, etc.) disrupts the travel path and thus causes inaccurate optical interference measurement results (i.e., the resultant beams 206 and 208 are not at the correct positions and/or the correct distance
20 apart for accurate measurement). Therefore, H1 measurements may only be taken towards the center of the ridges 64 (if at all). This prevents appropriate compensation for surface irregularities 76 in the mock disc 48. Also, a separate device must be used to determine a minimum and maximum light intensity for the flying height tester, a necessary step in calibration, as explained below. This separate device adds cost and complexity to
25 the calibration process.

[0006] It is therefore desirable to have a system and method for calibrating flying height testers that avoids the above-mentioned problems, as well as having additional benefits.

[0007] In an aspect of the present invention, a method for calibrating a gap measuring tool comprising: providing a calibration standard including at least one mock slider to be in

contact with a mock disc, said slider including a recessed portion, said recessed portion being a slider surface recessed with respect to a disc surface; determining an actual distance between said disc and a surface of the recessed portion of said slider at at least one location; determining by optical measurement an observed distance between said disc and surface of recessed portion of said slider at said at least one of said locations; and comparing said observed distance to said actual distance at each of said locations.

[0008] In a further aspect of the present invention, a system for calibrating a gap measuring tool comprising: a calibration standard including at least one mock slider to be in contact with a mock disc, said slider including a recessed portion, said recessed portion being a slider surface recessed with respect to a disc surface, wherein an actual distance between said disc and said surface of recessed portion of said slider is determined at at least one location; an observed distance between said disc and said surface of recessed portion of said slider is determined by optical measurement at said at least one of said locations; and said observed distance is compared to said actual distance at each of said locations.

[0009] In a still further aspect of the present invention, a method for calibrating a gap measuring tool comprising: providing a calibration standard including at at least one mock slider to be in contact with a mock disc, said slider including a mock slider having an inclined surface, said inclined surface maintaining a gap varying with position between said disc and said slider; determining an actual gap size between said disc and said inclined surface at least one location; determining by optical measurement an observed gap size between said disc and said inclined surface at said at least one of said locations; developing a plurality of curves representative of light intensity with respect to location on said inclined surface, each curve associated to a specific light frequency; and for each of a plurality of locations, associating a combination of light intensity values to their respective measured gap size.

Brief Description Of The Drawings

[0010] Figure 1 provides an illustration of a typical hard disc drive.

[0011] Figure 2 illustrates a typical device used to calibrate a flying height tester.

5 [0012] Figure 3 illustrates a flying height tester calibration standard according to an embodiment of the present invention.

[0013] Figure 4 illustrates surface irregularity compensation and provides further detailed illustrations of two mock heads according to an embodiment of the present invention.

10 [0014] Figure 5 provides a graphical illustration of the 'unique fit' solution utilized for providing a continuous spectrum of uniquely-valued combinations associatable to a range of head/disc gaps under principles of an embodiment of the present invention.

[0015] Figure 6 provides an illustration of a mock head design according to an alternative embodiment of the present invention.

[0016] Figure 7 provides illustrations of three mock head designs according to alternative embodiments of the present invention.

Detailed Description

[0017] Figure 3 illustrates a flying height tester calibration standard according to an embodiment of the present invention. As can be seen in figure 3a, in one embodiment, the calibration standard 100 includes a transparent mock disc 10 and one or more mock heads 20 placed in substantial contact with the mock disc 10 by one or more load springs 40. In this embodiment, a cover 50 is utilized to protect the standard from contaminants such as dust and debris. In this embodiment, two screws 71,72 are used to secure the cover 50 (and thus, the mock heads 20) to the mock disc 10. In this embodiment, the mock disc 10 is made of a substantially smooth, transparent material such as glass. Further, in this embodiment, the mock head 20 is provided an overcoat by thin film chemical deposition to emulate the optical properties of a head/slider.

[0018] In one embodiment, the height standard 100 plays two roles: a light intensity calibration tool and a height calibration tool. As a light intensity calibration tool, an inclined surface 22 on one or more of the mock heads 20 is utilized. As shown in figure 3b, in one embodiment, the light source 80 of the flying height tester is moved (with respect to the standard) along the inclined surface 22. As the tester is passed over the inclined surface 22, optical interference techniques (described below) yield an oscillating, continuous spectrum containing segments of high intensity light as well as darker segments. From this continuous spectrum, values for both maximum light intensity and minimum light intensity received at the detector 90 can be established. In this embodiment, the values of light intensity are stored in a computer (not shown) associated to the flying height tester.

[0019] After establishing the range of light intensity for the flying height tester, in an embodiment, the depth (flying height) of at least one surface recess 302 is measured with the flying height tester to determine at least one 'observed' distance between the disc 10 and surface 23 of recessed portion 302. In this embodiment, the physical dimensions of the mock head 20 may be determined by a device, such as an atomic force microscope (AFM), and thus, the 'actual' distance between the disc 10 and the surface 23 of the recessed portion 302 can be compared to the 'observed' distance for calibration of the

flying height tester. The differential between 'actual' and 'observed' distance is used to adjust the flying height tester for calibration. In one embodiment, multiple recessed portions 302 of differing depths (heights) are provided to improve calibration (calibration for different heights). Also, because the dimensions of the inclined surface 22 are known, it can be used to perform gap calibration as well (i.e., depth being known at any position x).

[0020] As explained, in one embodiment of the present invention, to calibrate a flying height tester, the calibration standard 100 is placed in the flying height tester in place of the original glass disc (not shown) of the tester under the tester's light source 80. As shown in figures 3b and 3c, in calibrating the flying height tester, height measurements are taken by the tester, yielding 'observed' distances. The 'observed' distances are compared with the 'actual' distances at those locations. In one embodiment, a linear translator and computer (not shown) are utilized to position the standard 100 appropriately for measurement. In this embodiment, at each measurement point, monochromatic light 88a is directed at the (transparent) mock disc 10 by the light source 80, as shown in fig. 3b. The light 88a impinges the disc 10 at an angle incident θ to a first mock disc surface 12 and continues through the (glass) mock disc 10 along path 88b to a second mock disc surface 11, where it splits and is partially reflected. The reflected portion follows path 88c through the disc 10 to the first surface 12, and follows path 88d to a sensor 90 of the flying height tester (not shown). The remaining light follows path 88e to the mock slider (head) surface 22 where it is reflected to the mock disc 10 via path 88f. The light impinges the second surface 11 of the mock disc 10, follows path 88g through the disc 10 and follows path 88h to the tester sensor 90. The slight angular deviations between paths at the air/disc interface are due to the Snell effect. Both the height h_2 and the incident angle θ have been exaggerated in figure 3b for illustrative purposes. Path 88a is actually substantially normal to the mock disc surface 12 with typical flying height testers.

[0021] Figure 4 illustrates surface irregularity compensation and provides further detailed illustrations of two mock heads according to an embodiment of the present invention. As seen in figure 4a, because of surface irregularities upon the top of each mock head 20, the distance, H_e , from disc to mock head surface 21 varies with position. In one embodiment

of the present invention, the mock head's surface profile may be determined by a device such as a profilometer. This surface profile, combined with the knowledge of the 'actual' dimensions of the mock head 20 (by AFM, etc.) enable improved calibration. The true depth H_a of the recessed portion of the mock head 20 is slightly different than the apparent depth H_1 (because of high points 402 on the mock head 20 surface). Utilizing H_a as the 'actual' distance provides a more accurate value. In an embodiment, the acquired surface irregularity information may be used by the flying height tester computer to provide a correction factor or a series of correction factors for the calibration.

[0022] Figures 4b and 4c further illustrate a mock head slider 20 with a recessed surface 23 and inclined surface 22 (see figure 4b) and a mock head slider 20 with a series of recessed surfaces (grooves) 23 at varying depths (see figure 4c) under an embodiment of the present invention. In one embodiment, recessed surface 23 length L_1 is greater than 50 microns, and the recessed surface 23 depth (flying height) H_1 is greater than 2 nanometers. In one embodiment, inclined surface height (rise) H_2 is between 12 and 13 microinches (.31-.33 microns), and inclined surface 22 length (run) L_2 approaches 100 mils (2,540 microns). As stated above, the mock heads 20 can be used together in a calibration standard 100 (see figure 3a), or they can be used alone in a calibration standard 100.

[0023] Figure 5 provides a graphical illustration of the 'unique fit' solution utilized for providing a continuous spectrum of uniquely-valued combinations associatable to a range of head/disc gaps under principles of an embodiment of the present invention. In one embodiment, light of multiple wavelengths (e.g., three wavelengths 501,502,503) is directed at the surface to be measured. In one embodiment, upon varying the distance between the mock head and mock disc to obtain the maximum and minimum light intensity (for light intensity calibration), multiple curves may be developed. After calibrating light intensity at the different wavelengths (equalizing amplitude), the wavelengths displayed superimposed provide multiple curves that may be utilized for a 'unique fit' solution spectrum. By optical interference, light intensity 524 received by the detector oscillates repeatedly between the maximum 526 and the minimum 528 as the distance measured increases (or decreases). Although each curve passes through the same light intensity

values multiple times as the measured distance increases (or decreases) through the range of possible values, the combination of values 511,512,513 provided by the multiple-wavelength light source is unique for each distance in the range of possible distances 522. This 'unique fit' solution provides a range of light intensity combinations that is directly and uniquely associatable to the range of possible distances to be measured.

[0024] According to embodiments of the present invention, a calibration device is provided for both light intensity / unique fit theory curves (inclined surface; See, e.g., figure 4b) and for specific depth (flying height) measurement calibration (recessed surface; See, e.g., figure 4c). In this embodiment, both mock heads are provided in the same calibration standard (as opposed to requiring a separate standard/device). As stated previously, typical calibration standards in the art provide no more than a series of grooves for gap calibration (on the disc side, not on the head side). For light intensity calibration and the development of theory curves, a separate component (a wedge piece) would need to be added, adding cost to the manufacture and operation. Therefore, in addition to the advantages of having varying-depth grooves on the mock head (as opposed to on the mock disc; as explained above), having all parts integrated in a single calibration standard is advantageous from both a complexity and a cost standpoint. Further, the process of forming grooves (by, e.g., ion milling or chemical etching) in a mock disk of glass, for example, is more difficult because of its hardness than forming similar grooves in a mock head (substrate). Further, etching glass with such methods produces surface roughness (irregularities) as large as 0.4 microinches (~10 nanometers) or more, exacerbating calibration difficulties.

[0025] Further, employing optical interference techniques with calibration grooves formed in the mock disc 44, such as in the prior art (see figure 2a), causes significant inaccuracies. If a measurement location is too close to the edge of a ridge 64, one or more of the light beam's return paths may pass through the air 212 (glass-air-glass, rather than just glass), altering the path of the light (see figure 2c). Because the distance in which one of the light beam travels through air defines the height measurement perceived, the light

should travel through consistent paths through the glass (i.e., uniform thickness mock disc, such as the present invention).

[0026] Figure 6 provides an illustration of a mock head design according to an alternative embodiment of the present invention. In this embodiment, the mock head 20 has two separate inclined surfaces 22,24. In this embodiment they can be formed with differing slopes ($H2/L2$ and $H4/L4$). An inclined surface 22,24 with a shallow slope could be used for fine adjustment calibration and an inclined surface 22,24 with a steeper slope could be used for large range adjustment.

[0027] Figure 7 provides illustrations of three mock head designs according to alternative embodiments of the present invention. As shown in figure 7a, in one embodiment, the mock head 20 has a cylindrically convex (curved) portion 702 and a recessed surface portion 704. In this embodiment, the cylindrical portion 702 is used for light intensity calibration and gap spectrum calibration (via light intensity curves, as explained above). In this embodiment, the dimensions of the cylindrical portion 702 may be determined by AFM and known geometric principles to yield 'actual' (flying height) distances H 706 (similar to inclined surface 22; see figure 3b). Similar to above, in this embodiment, the recessed portion 704 is utilized for specific flying height calibration. As illustrated in figure 7b, in another embodiment, a mock head 20 with a cylindrical portion 702 is utilized in the calibration standard. In this embodiment, the cylindrical portion 702 is used for light intensity calibration, gap spectrum calibration (via light intensity curves), and specific flying height calibration. In this embodiment, specific gap measurement calibration (via 'actual' vs. 'measured' differential) is taken at a desired location. As stated the 'actual' distance is known by a device such as an AFM. In another embodiment, the curved surface 702 of the designs shown in figure 7a and 7b is a spherical (convex) surface. In an alternative embodiment, as shown in figure 7c, a curved surface 702 (e.g., spherical, cylindrical, etc.) occupies the top portion of a mock head 20 with an inclined surface portion, providing further flexibility of calibration.

[0028] Although several embodiments are specifically illustrated and described herein, it will be appreciated that modifications and variations of the present invention are covered

by the above teachings and within the purview of the appended claims without departing from the spirit and intended scope of the invention.

What is claimed is

1. A method for calibrating a gap measuring tool comprising:
 - providing a calibration standard including at least one mock slider to be in contact with
 - 5 a mock disc, said slider including a recessed portion, said recessed portion being a slider surface recessed with respect to a disc surface;
 - determining an actual distance between said disc and a surface of the recessed portion of said slider at at least one location;
 - determining by optical measurement an observed distance between said disc and
 - 10 surface of recessed portion of said slider at said at least one of said locations; and
 - comparing said observed distance to said actual distance at each of said locations.
2. The method of claim 1, further comprising calibrating said gap measuring tool based on
- the differential between each measured distance and its associated actual distance.
- 15
3. The method of claim 1, further comprising:
 - determining a surface profile; and
 - compensating for surface irregularities based on said profile.
- 20 4. The method of claim 3, wherein said determining a surface profile is by a profilometer.
5. The method of claim 1, further comprising providing a mock slider having an inclined surface, said inclined surface maintaining a space between said disc and said slider varying with respect to position.
- 25
6. The method of claim 5, further comprising forming said recessed portion of said slider by a chemical deposition process.
7. The method of claim 5, wherein said determining said actual distance is performed by an

atomic force microscope (AFM).

8. The method of claim 5, wherein said calibration standard is shielded from contamination by a cover.

5

9. The method of claim 5, wherein contact is maintained between said mock slider and said mock disc by at least one spring.

✓ 10. The method of claim 5, wherein said gap varies with location.

10

11. The method of claim 10, wherein said gap varies in a manner selected from the group consisting of: linearly, parabolically, curvingly, and concavely.

12. The method of claim 5, wherein said optical measurement includes an optical interference measurement.

15

13. The method of claim 12, further comprising:

determining an actual gap size between said disc and said inclined surface at one or more locations;

20 determining by optical measurement an observed gap size between said disc and said inclined surface at one or more of said locations; and

comparing said observed gap size to said actual gap size at each of said locations.

14. The method of claim 13, further comprising:

25 developing a plurality of curves representative of light intensity with respect to location on said inclined surface, each curve associated to a specific light frequency; and

for each of a plurality of locations, associating a combination of light intensity values to their respective measured gap size.

15. The method of claim 13, further comprising:

for each location, comparing the measured gap size to the actual gap size; and
calibrating said gap size measuring tool based on the differential between each
measured gap size and its associated actual gap size.

5

16. The method of claim 14, further comprising:

utilizing the light intensity curves to determine a minimum light intensity and a
maximum light intensity.

10 17. The method of claim 16, further comprising:

calibrating said gap size measuring tool based on said minimum light intensity and said
maximum light intensity.

18. A system for calibrating a gap measuring tool comprising:

15 a calibration standard including at least one mock slider to be in contact with a mock
disc, said slider including a recessed portion, said recessed portion being a slider surface
recessed with respect to a disc surface, wherein

an actual distance between said disc and said surface of recessed portion of said slider
is determined at at least one location;

20 an observed distance between said disc and said surface of recessed portion of said
slider is determined by optical measurement at said at least one of said locations; and
said observed distance is compared to said actual distance at each of said locations.

19. The system of claim 18, wherein said gap measuring tool is calibrated based on the
25 differential between each measured distance and its associated actual distance.

20. The system of claim 18, wherein an irregularity gap between said disc and a top surface
of said slider is determined by optical measurement at one or more locations.

21. The system of claim 18, wherein said mock slider has an inclined surface, said inclined surface maintaining a space between said disc and said slider varying with respect to position.
- 5 22. The system of claim 21, wherein said recessed portion of said slider is formed by a chemical deposition process.
23. The system of claim 21, wherein said actual distance is determined by an atomic force
✓ microscope (AFM).
- 10 24. The system of claim 21, wherein said calibration standard is shielded from contamination by a cover.
25. The system of claim 21, wherein contact is maintained between said mock slider and
15 said mock disc by at least one spring.
26. The system of claim 21, wherein said gap varies with location.
27. The system of claim 26, wherein said gap varies in a manner selected from the group
20 consisting of: linearly, parabolically, curvingly, and concavely.
28. The system of claim 21, wherein said optical measurement includes an optical interference measurement.
- 25 29. The system of claim 28, wherein an actual gap size between said disc and said inclined surface is determined at one or more locations; an observed gap size between said disc and said inclined surface is determined by optical measurement at one or more of said locations; and said observed gap size is compared to said actual gap size at each of said locations.

30. The system of claim 29, wherein a plurality of curves representative of light intensity with respect to location on said inclined surface are developed, each curve associated to a specific light frequency; and

for each of a plurality of locations, a combination of light intensity values is associated
5 to the respective measured gap size.

31. The system of claim 29, wherein for each location, the measured gap size is compared to the actual gap size; and the gap size measuring tool is calibrated based on the differential between each measured gap size and its associated actual gap size.

10

32. A method for calibrating a gap measuring tool comprising:

providing a calibration standard including at least one mock slider to be in contact with a mock disc, said slider including a mock slider having an inclined surface, said inclined surface maintaining a gap varying with position between said disc and said slider;

15 determining an actual gap size between said disc and said inclined surface at at least one location;

determining by optical measurement an observed gap size between said disc and said inclined surface at said at least one of said locations;

20 developing a plurality of curves representative of light intensity with respect to location on said inclined surface, each curve associated to a specific light frequency; and

for each of a plurality of locations, associating a combination of light intensity values to their respective measured gap size.

33. The method of claim 32, further comprising:

25 for each location, comparing the measured gap size to the actual gap size; and

calibrating said gap size measuring tool based on the differential between each measured gap size and its associated actual gap size.

Abstract

A system and method are disclosed for calibrating a hard disc drive magnetic head flying height tester by a calibration standard, which includes a mock slider and mock disc,
5 by optical interference techniques.

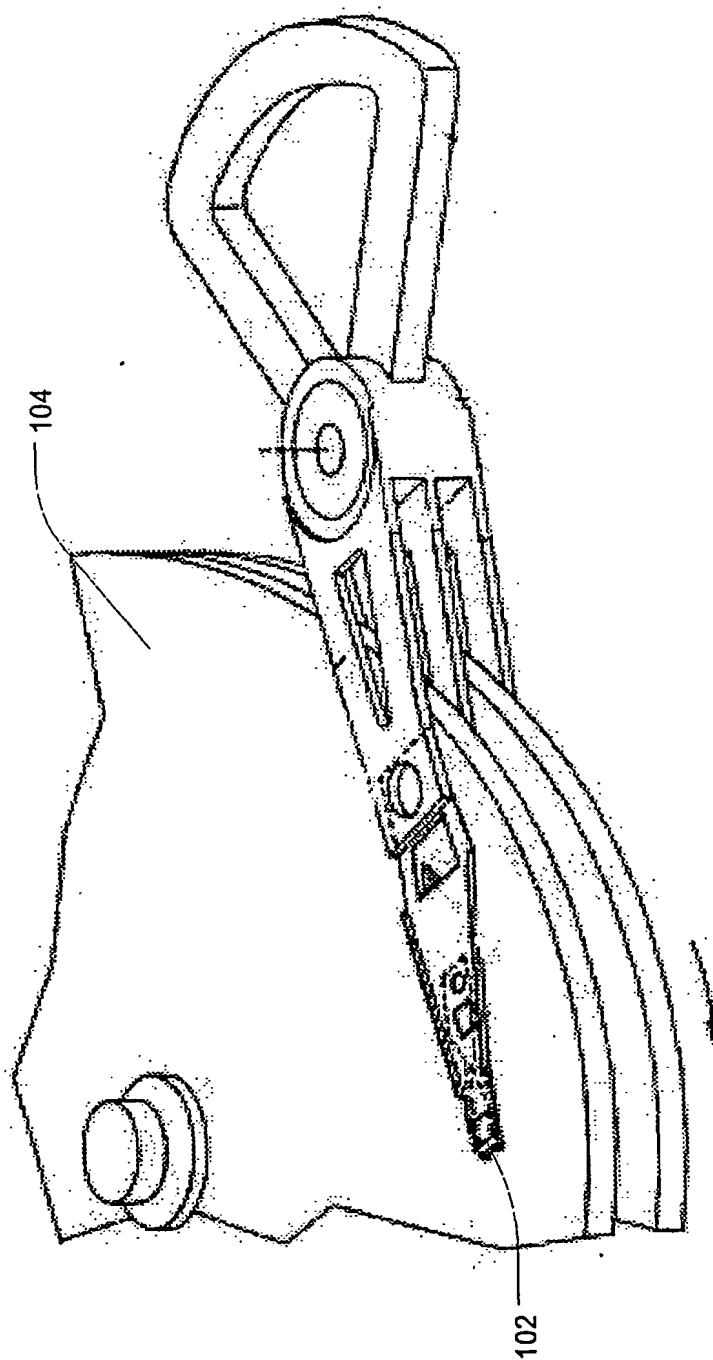


FIG. 1
(Prior Art)

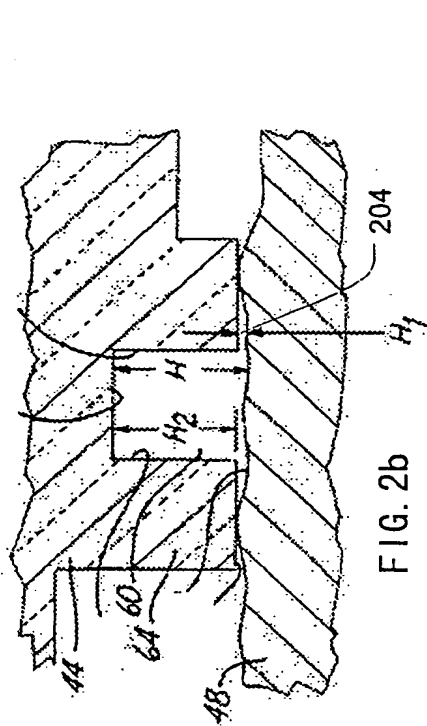


FIG. 2b

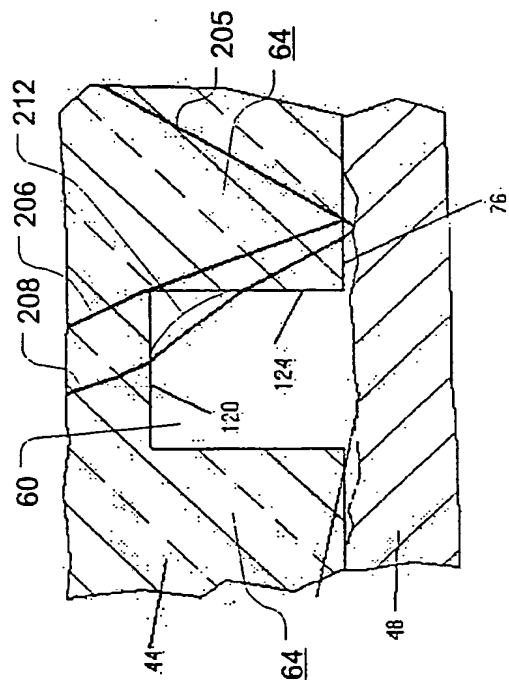


FIG. 2c

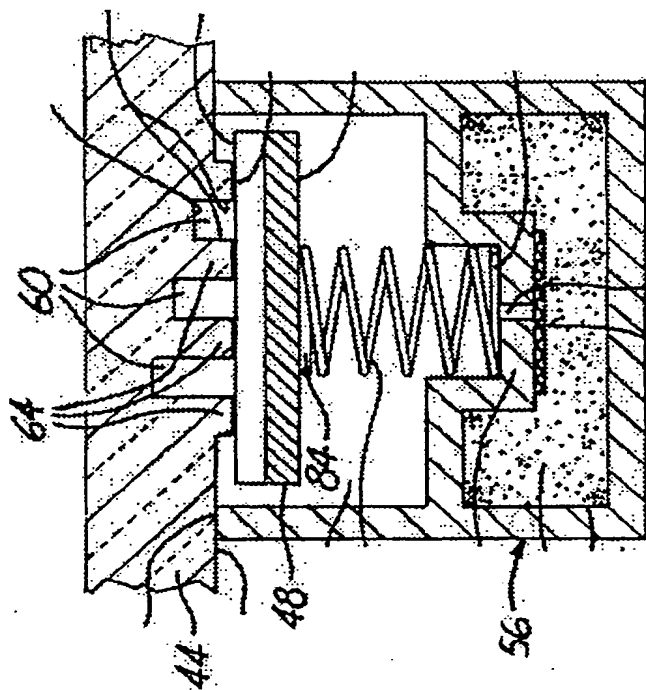


FIG. 2a

FIG. 2
(Prior Art)

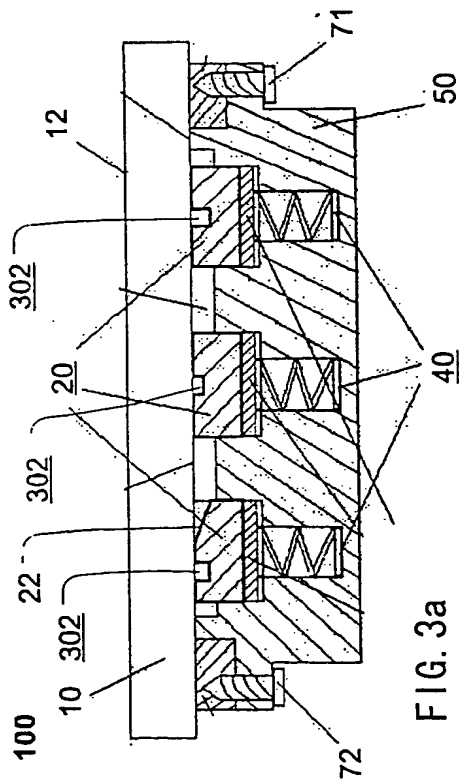


FIG. 3a

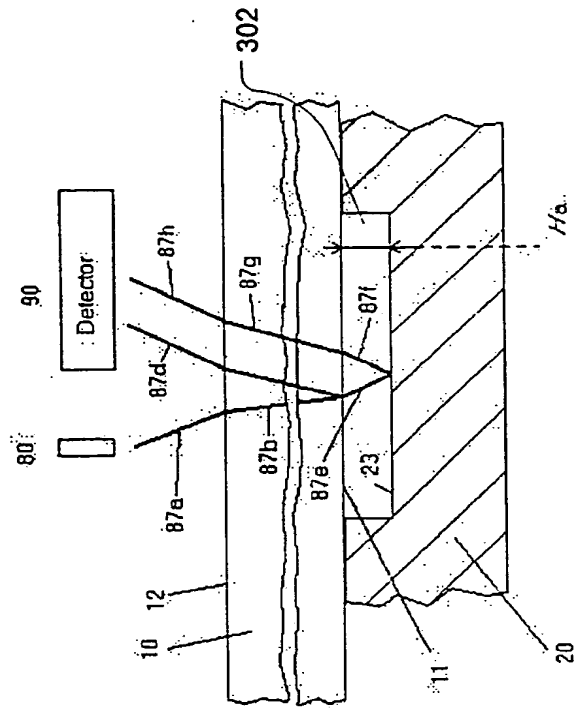


FIG. 3b

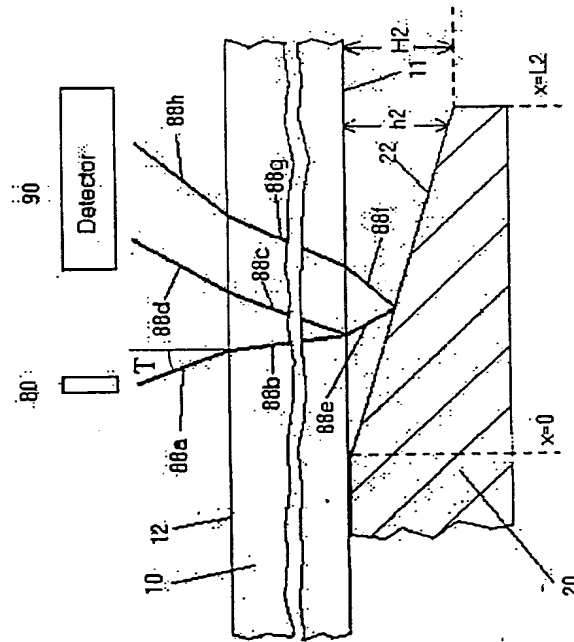


FIG. 3c

FIG. 3

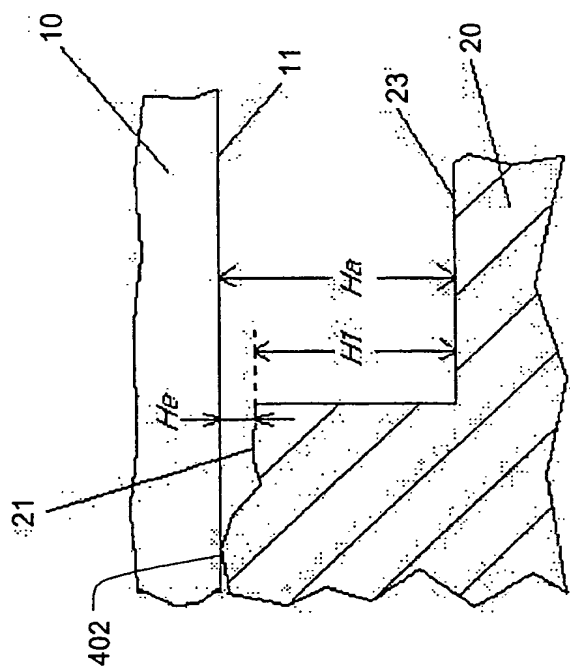


FIG. 4a

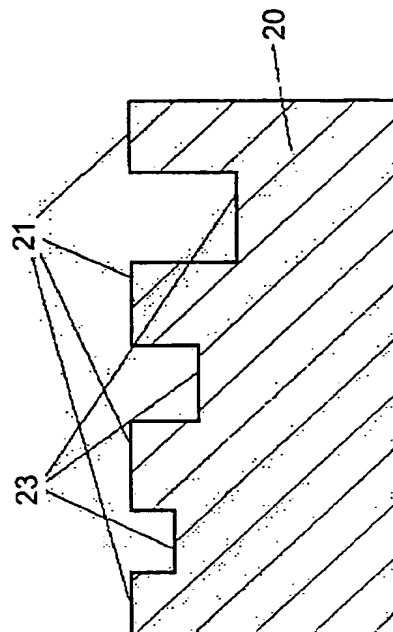


FIG. 4c

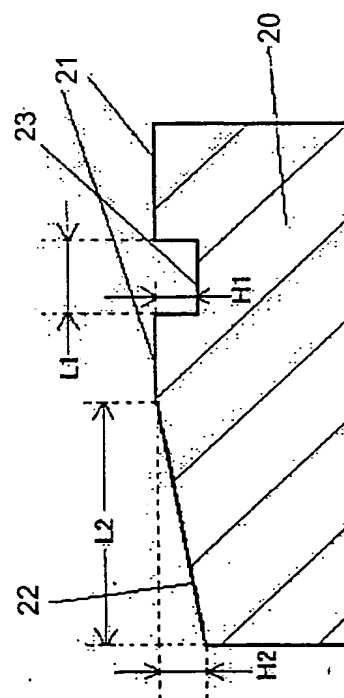


FIG. 4b

FIG. 4

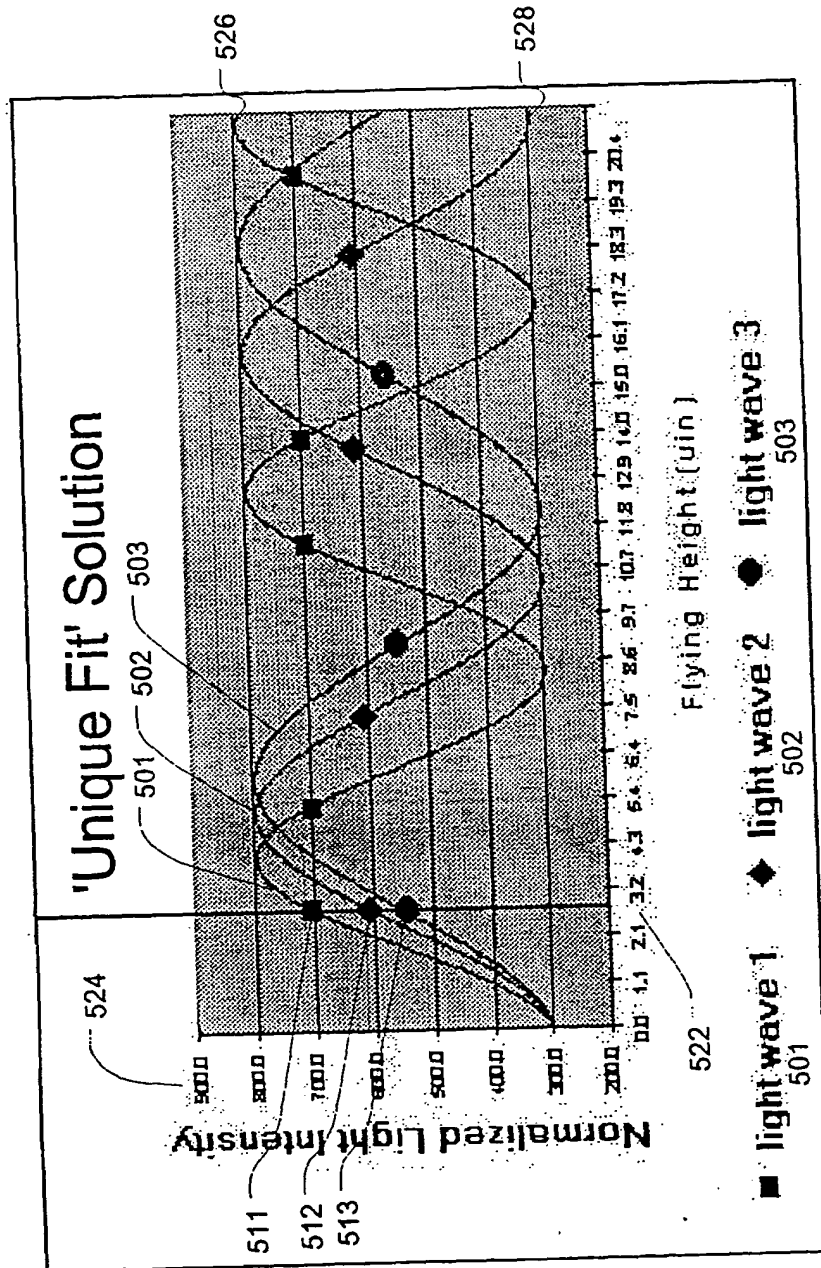


FIG. 5

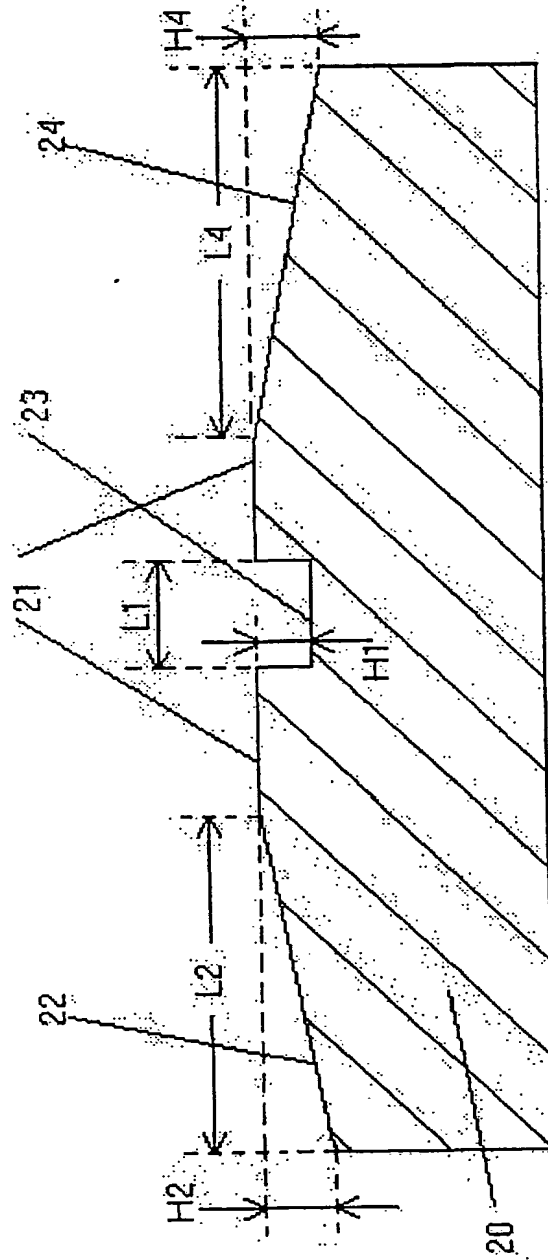


FIG. 6

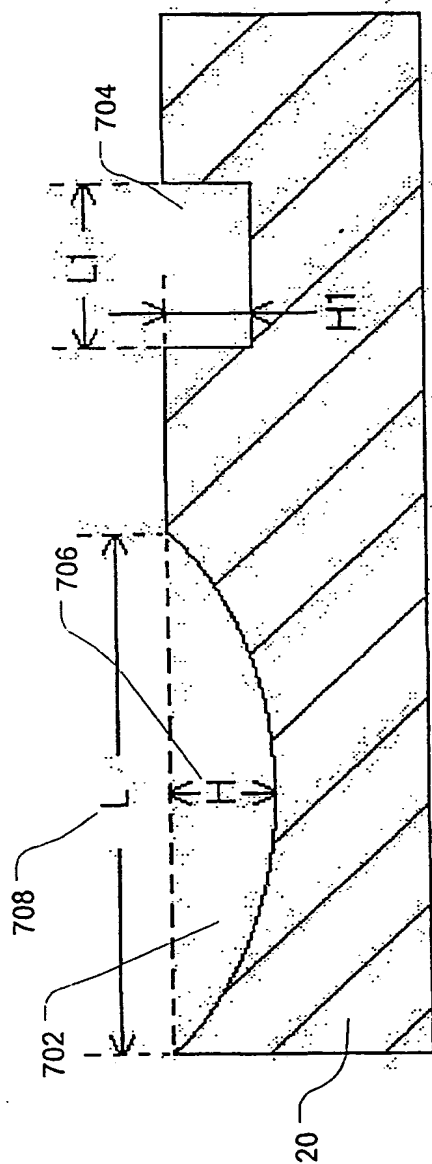


FIG. 7a

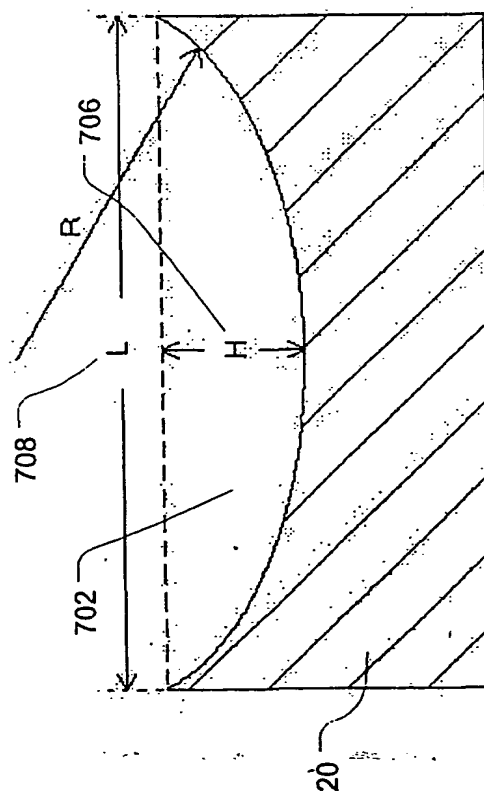


FIG. 7b

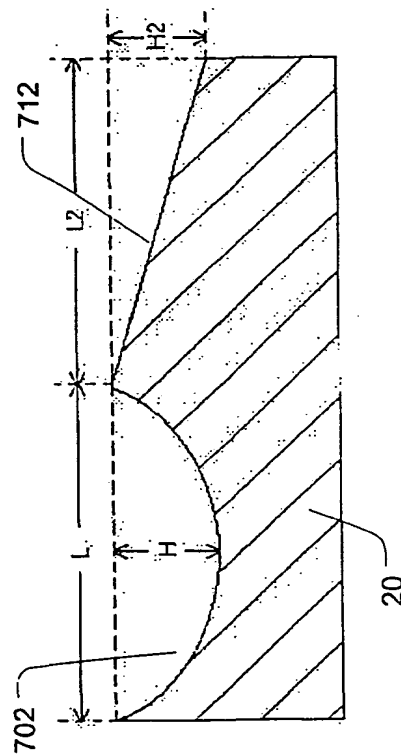


FIG. 7c

FIG. 7